



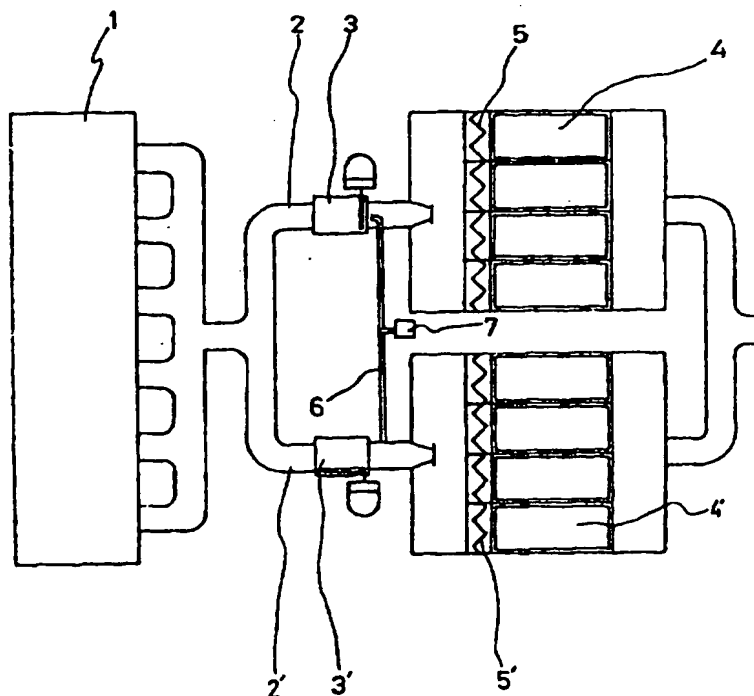
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(54) Title: DEVICE FOR REMOVING PARTICULATE MATERIALS FROM EXHAUST GAS OF DIESEL VEHICLES

(57) Abstract

A device for removing particulate materials from the exhaust of diesel vehicles is disclosed. The device prevents the exhaust gas from flowing to filters (4, 4') during a filter regeneration, thus preventing the incomplete removal of filtered harmful particulate materials and easily reheating the filters (4, 4') and preventing the overheating of the filters (4, 4'). The device has a direct heating mechanism (5, 5') in place of a conventional indirect heating mechanism, thus being free from the need for an additional battery or an increase of the alternator's capacity. The device also prevents the harmful particulate materials from accumulating on the central portion of each filter (4, 4') thus allowing all portions of each filter (4, 4') to be uniformly regenerated at a low temperature.



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DEVICE FOR REMOVING PARTICULATE MATERIALS FROM
EXHAUST GAS OF DIESEL VEHICLES

BACKGROUND OF THE INVENTION

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Field of the Invention

The present invention relates, in general, to a device for removing particulate materials from the exhaust gas of the diesel vehicles by filtering off harmful particulate materials from the exhaust gas and by burning the filtered particulate materials and, more particularly, to a structural improvement in such a device for lengthening the expected durability of filters installed in the device and for safely burning the filtered particulate materials at a low temperature.

Description of the Prior Art

As well known to those skilled in the art, exhaust gas from the diesel vehicles includes a large amount of harmful particulate materials such as soot and unburnt hydrocarbons caused by incomplete combustion of diesel vehicles. Such particulate materials included in the exhaust gas cause various diseases such as lung cancer of the human body, so that various methods of restricting and reducing the amount of harmful particulate materials included in the exhaust gas have been actively studied.

The methods of restricting and reducing the amount of harmful particulate materials included in the exhaust gas are generally classified into three types: a) a method of restricting the generation of unburnt materials in the exhaust gas by structurally improving engines, b) a method of reducing the unburned portion of fuel by adding fuel additives and c) after-treatment of the harmful particulate materials. Method "a" or "b" of restricting and reducing the amount of harmful particulate materials by structurally improving the engines or by adding fuel additives somewhat effectively improves the combustion efficiency of engines thereby reducing the amount of harmful materials such as harmful particulate materials and harmful gases. However, methods "a" and "b" are problematic in that they are expensive and are confronted with a technical limit. Due to the technical limit, methods "a" and "b" regrettably fail to completely reduce the amount of harmful particulate materials included in the exhaust gas. In this regard, method "c" of restricting and reducing the amount of harmful particulate materials by after-treatment the particulate materials has been most actively studied recently.

The method of after-treatment the harmful particulate materials generally comprises two steps: a first step of filtering off the particulate materials from the exhaust gas using filters and a second step of burning the filtered particulate materials thereby regenerating the

filters. In order to burn the filtered particulate materials and to regenerate the filters in the prior art, the filtered particulate materials may be burnt by a) an external heat source such as a diesel burner, electric
5 heater or a combustion agent injector, b) increasing the exhaust gas temperature by throttling the exhaust of engine and c) reducing the oxidation activating energy by adding a catalyst to the fuel or by impregnating the filters with a catalyst and thereby burning the
10 particulate materials at a low temperature.

A typical filter regenerating device using a heater as the external heat source is problematic in that it is unstable in opening or closing the exhaust passage and it is necessary to use an oxygen supply means while burning
15 the filtered particulate materials and it is necessary to use a large amount of electric current while maintaining a suitable temperature of the heater. Another problem of the above device resides in that the thermal stability of the filters is reduced thus reducing the durability of the
20 device.

That is, a typical device for removing harmful particulate materials from the exhaust gas of the diesel vehicles uses a butterfly-type valve while opening or closing the exhaust pipe. Even if the butterfly-type
25 valve installed in the exhaust pipe is fully closed, a gap of about 0.2 mm is needed between the valve seat and the hinged valve body and passes the exhaust gas to the

particulate burning filters thus causing a loss of heat generated from an electric heater. Due to the heat loss, the filters may not be ignited or may be unexpectedly extinguished prior to completely burning the particulate materials leaving residue in the filters, thus causing difficulty while trying to regenerate the filters again. Even if the filters are reheated to burn the particulate materials, the filters are regenerated with an excessive amount of particulate materials remaining in the filters, so that the filters may be overheated. When the filters are overheated, the filters may melt or be broken due to excessive thermal stress within the filters.

The above device must be provided with an air source, such as an air compressor or a blower, for supplying oxidizer while regenerating the filters, thus forcing excessive costs on the owner and complicating the construction of the device and adding the possibility of breakdown. The device also uses an indirect heating mechanism which includes a heater spaced apart from the filters. In the above indirect heating mechanism, the filtered harmful particulate materials are burnt by radiant heat and convection heat, so that the electric energy penalty is very high. Therefore, in the above device, it is necessary to install an additional battery or it is necessary to increase the alternator's capacity.

Another problem of the above device is caused by the structure of the filters which are used for filtering off

harmful particulate materials from the exhaust gas. That is, the device uses conventional honeycomb filters. While regenerating the wall flow type filters, the central portion of each filter is remained at a high temperature, while the edge portion of each filter at a low temperature. Such a big gradient of temperature between the central and edge portions of each filter reduces the durability of the filters.

10 SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a device for removing particulate materials from the exhaust gas of the diesel vehicles in which the above problems can be overcome and which has a simple construction, reducing the manufacturing cost of the device and causing the device to be less likely to break down.

Another object of the present invention is to provide a device for removing particulate materials from the exhaust gas of the diesel vehicles, which prevents the exhaust gas from flowing to filters during regenerating the filter, thus preventing the incomplete removal of harmful particulate materials and easily reheating the filters and preventing the overheating of the filters while reheating the filters.

A further object of the present invention is to

provide a device for removing particulate materials from the exhaust gas of the diesel vehicles, which has a direct heating mechanism in place of the conventional indirect heating mechanism, thus being free from the need for an additional battery or an increase of the alternator's capacity and thereby reducing the manufacturing cost of the device.

Still another object of the present invention is to provide a device for removing particulate materials from the exhaust gas of the diesel vehicles, which effectively prevents the harmful particulate materials from accumulating on the central portion of each filter thus allowing all portions of each filter to be uniformly regenerated at a low temperature.

In order to accomplish the above objects, the present invention provides a device for removing particulate materials from the exhaust gas of the diesel vehicles, comprised of an exhaust pipe extending from an exhaust manifold of an engine and branched into two branch pipes; valve means provided in at least one of the branch pipes and adapted for selectively opening or closing the branch pipe, the valve means being provided with a valve body for selectively opening or closing an exhaust inlet port of a valve case; filter means connected to at least one of the branch pipes and adapted for filtering off the particulate materials from the exhaust gas, the central portion of the filter means being plugged with the ratio of the plugged

area to the total area of the filter means ranging from 5 % to 40 %; electric heating means installed on the front of the filter means in a way such that a heating coil of the heating means is brought into close contact with the filter means, the electric heating means selectively burning and removing the particulate materials accumulating on the filter means thus regenerating the filter means when the particulate accumulating ratio of the filter means exceeds a predetermined regeneration point; and a breather pipe extending between the two branch pipes at a position between the valve means and the filter means, thus causing the branch pipes to communicate with each other through the breather pipe.

15 BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a view showing the construction of a harmful particulate removing device in accordance with the primary embodiment of the present invention;

Fig. 2 is a sectional view showing the construction and position of an exhaust pipe control valve or a trap valve included in the device of this invention;

Fig. 3 is a sectional view showing the operation of

the trap valve of Fig. 2;

Fig. 4 is a sectional view showing the construction of an oxidizer supply means included in the device of this invention;

5 Fig. 5 is an exploded perspective view showing the construction of an electric heating means included in the device of this invention;

Fig. 6 is a sectional view of the above electric heating means, with the parts of Fig. 5 being assembled
10 into a single body;

Fig. 7 is a plan view of the above electric heating means;

Fig. 8 is a plan view showing the construction of a particulate filter in accordance with an embodiment of the
15 present invention;

Fig. 9 is a plan view showing the construction of a particulate filter in accordance with another embodiment of the present invention;

Fig. 10 is a view showing the construction of a
20 harmful particulate removing device in accordance with the second embodiment of the present invention; and

Figs. 11a and 11b are views showing breather pipes of this invention used with harmful particulate removing devices which leak the exhaust gas into the atmosphere
25 during a filter regeneration different from the devices of Figs. 1 and 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 1 is a view showing the construction of a harmful particulate materials removing device in accordance with the primary embodiment of this invention. Fig. 2 is a sectional view showing the construction and position of an exhaust pipe control valve or a trap valve included in the above device. Fig. 3 is a sectional view showing the operation of the above trap valve. Fig. 4 is a sectional view showing the construction of an oxidizer supply means included in the above device. Fig. 5 is an exploded perspective view showing the construction of an electric heating means included in the above device. Fig. 6 is a sectional view of the above electric heating means, with the parts of Fig. 5 being assembled into a single body. Fig. 7 is a plan view of the above electric heating means. Fig. 8 is a plan view showing the construction of a particulate filter in accordance with an embodiment of this invention. Fig. 9 is a plan view showing the construction of a particulate filter in accordance with another embodiment of this invention. In the drawings, the reference numeral 1 denotes an engine of the diesel vehicles, the numeral 2, 2' denotes an exhaust pipe, the numeral 3, 3' denotes an exhaust pipe control valve or a trap valve, the numeral 4, 4' denotes a particulate filter, the numeral 5, 5' denotes an electric heating means, the numeral 6 denotes a breather pipe, the numeral

7 denotes a relief valve, the numeral 11 denotes a valve case, the numeral 14 denotes a valve body, the numeral 15 denotes a hinged valve rod, the numeral 29 denotes a heating coil and the numeral 33 denotes a heat reflector.

5 As shown in the drawings, the particulate removing device of this invention comprises an exhaust pipe, which extends from an exhaust manifold of the engine 1 and is branched into two branch pipes 2 and 2'. Each branch of the exhaust pipe 2, 2' is provided with a trap valve 3, 3' 10 which opens or closes the pipe 2, 2'. The exhaust pipes 2 and 2' extend to the particulate filters 4 and 4', respectively. An electric heating means 5, 5' is installed in the exhaust inlet part of each filter 4, 4'. As shown in Figs. 2 and 3, each trap valve 3, 3' includes 15 a shaft 19 which is held by a shaft holder 18 formed on the inner wall of a valve case 11. Fixed to the shaft 19 is one end of a valve rod 15. The other end of the valve rod 15 holds a valve body 14 which is selectively seated on the valve seat of the valve case 11 thus selectively 20 closing the exhaust inlet port 12 of each exhaust pipe 3, 3'. The valve rod 15 loosely holds the valve body 14, with a gap 17 being formed between the valve body 14 and the valve rod 15. Due to the gap 17, the valve body 14 is brought into uniform contact with the valve seat formed on 25 the exhaust inlet port 12. The one end of the valve rod 15 has a fitting part 16 which is fitted over the shaft 19. The fitting part 16 of the rod 15 has a fitting hole

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of an oval cross-section, while the shaft 19 has an oval cross-section corresponding to that of the fitting hole formed in the fitting part 16. Both sides of the above oval cross-section are flat, so that the rod 15 is rotated up or down in accordance with a rotating motion of the shaft 19 thus causing the valve body 14 to open or close the exhaust inlet port 12.

The above shaft 19 extends outside the valve case 11 and is hinged to a connecting rod 20. The connecting rod 20 in turn is connected to the tip of a piston rod 23 of an actuating cylinder 22 at a position outside the valve case 11.

In order to hinge the shaft 19 to the connecting rod 20, the hinged end of the shaft 19 is flat-sided, while the hinged end of the connecting rod 20 is axially slitted in order to receive the flat-sided hinged end of the shaft 19 prior to connecting the hinged ends together using a pin. Therefore, the rod 20 converts a vertical linear reciprocating motion of the piston rod 23 into a rotating motion of the shaft 19. As well known to those skilled in the art, in order to safely regenerate the filters 4 and 4' of a particulate removing device used with a bus engine, the leaking rate of the exhaust gas from the valve must be lower than 30 ml/min at 2200 rpm which is the maximum rpm (revolutions per minute) of the bus engine. In accordance with the particulate removing device of this invention, it is possible to minimize the leaking rate of

the exhaust gas leaking from the trap valve while regenerating the filters under the maximum rpm condition, so that the device safely regenerates the filters.

As shown in Fig. 4, a breather pipe 6 extends between
5 the two exhaust pipes 2 and 2' at a position between the valve 3, 3' and the filter 4, 4'. Both ends of the breather pipe 6 are inserted into the pipes 2 and 2', thus causing the pipes 2 and 2' to communicate with each other through the breather pipe 6 and minimizing variation of
10 the air flow rate inside the breather pipe 6. A relief valve 7 is mounted to the middle portion of the breather pipe 6. The relief valve 7 prevents an abrupt increase of the pressure inside the breather pipe 6 and thereby prevents an excessive amount of air from being introduced
15 into a filter.

As shown in Figs. 5 to 7, each electric heating means
5 is cased by a housing 26. A positive (+) terminal fixing means 27 is formed on the side wall of the housing 26 and holds a positive terminal holder 28. The positive
20 terminal of a heating coil 29 is mounted to the holder 28, with a plurality of insulating discs 30 being fitted over the holder 28 in order to insulate the housing 26, holder 28 and positive terminal from each other. Meanwhile, a negative (-) terminal holder 31 is formed on the end wall
25 of the housing 26 and holds the negative terminal of the heating coil 29. An annular step 26' is formed on the inside end wall of the housing 26. When the electric

heating means 5 is installed on the filter 4, the annular step 26' biases the heating coil 29 toward the filter 4 thereby bringing the coil 29 into close contact with the surface of the filter 4.

5 A thermal-insulating ring 32 is installed inside the housing 26 and covers the annular side wall of the housing 26. The thermal-insulating ring 32 prevents heat loss of the heating coil 29 and relieves thermal shock.

10 A heat reflector 33 is received in the housing 26 at a position inside the thermal-insulating ring 32 and is perforated to form a plurality of exhaust openings 34. Since the heat reflector 33 is heated to a temperature of higher than 1000 °C when the heating coil 29 is turned on, the heat reflector 33 is preferably made of a fire-
15 resistant material including, for example, alumina or ball clay suitable for preventing thermal cracking of the plate 33. In the present invention, it is preferable to size the heat reflector 33 into an orthogonal projection size of the cross-sectioned area of the filter exposed to the
20 exhaust gas. However, the size of the heat reflector 33 is not limited to the above-mentioned size. In an electric heater used as a typical electric heating means, the heat reflector has a single function of reflecting the radiant heat when the heating coil generates heat.
25 However, in the electric heating means of this invention, the heat reflector 33 reflects the radiant heat when the heating coil generates heat, brings the heating coil 29

into close contact with the filter 4 and uniformly distributes the harmful particulate materials on the filter 4. The heat reflector 33 also has a coil holding means which stably holds the heating coil 29 in its place thus preventing the heating coil 29 from unexpectedly drooping or being bent due to the vibrations of a vehicle and heat generated from the heating coil 29. In the embodiment of Fig. 5, the coil holding means comprises a plurality of protrusions 35 which are formed on the heat reflector 33 at positions corresponding to the outside bent portions of the coil 29. However, it should be understood that the coil holding means may have another configuration. For example, the coil holding means may comprise a holding groove (not shown), which is formed on the heat reflector during a heat reflector molding process and has a configuration equal to that of the coil 29.

The height of each coil holding protrusion 35 or the depth of such a coil holding groove must be lower than the thickness of the coil 29, thus allowing the coil 29 to be brought into close contact with the filter 4 without failure. When the heating coil 29 fails to come into close contact with the filter 4, the front surface of the filter 4 is slowly heated and fails to concentrate heat. In the above state, it is impossible to start the filter regeneration process. Therefore, it is necessary to bring the heating coil 29 into close contact with the front surface of the filter 4.

When the heating coil 29 is arranged on the heat reflector 33 and is brought into close contact with the front surface of the filter 4 as described above, a gap which is equal to the thickness of the coil 29 is formed between the heat reflector 33 and the filter 4. Therefore, the heat reflector 33 may disturb the flow of the exhaust gas to the filter 4. However in accordance with an experiment of the device of this invention, the particulate materials of the exhaust gas smoothly pass to the filter 4, when the ratio (opening ratio of the heat reflector) of the total sum of the area of the exhaust openings 34 to the total area of the heat reflector 33 is not lower than 30 % and a gap, which is equal to the coil thickness, is formed between the heat reflector 33 and the filter 4. In the above experiment, when the opening ratio of the heat reflector 33 is lower than 30 %, the heat reflector 33 fails to smoothly pass the exhaust gas. In order to reduce temperature gradient within the filter and to completely regenerate the filter, the central portion of the heat reflector 33 is closed, with the ratio of a closed area to the total area of the plate 33 being not higher than 40 %. The closed central portion of the heat reflector 33 is brought into close contact with the filter, thus preventing the particulate materials from being introduced into the central portion of the filter. The heat reflector 33 thus effectively prevents the particulate materials from accumulating on the central

portion of the filter, so that it is possible to prevent the central portion of the filter from being overheated and to improve the regeneration rate of the edge portion of the filter.

5 As shown in Figs. 8 and 9, the central portion of the filter 4 is closed, with the ratio of the closed area to the total area of the filter ranging from 5 % to 40 %.

 The exhaust gas is introduced into the filter 4 through a plurality of exhaust inlet parts 37 and passes
10 through a porous wall and is exhausted from the filter through a plurality of exhaust outlet parts. The exhaust outlet parts of the filter 4 are formed by the rear ends of the closed parts 36. While the exhaust gas passes through the filter 4 as described above, the harmful
15 particulate materials are filtered off by the porous wall of the filter 4. Since the central portion of the filter 4 is closed as described above, the particulate materials do not accumulate on the central portion of the filter during a particulate filtering process thus preventing the
20 central portion of the filter 4 from being regenerated at a high temperature during a filter regeneration process. Therefore, the device of this invention effectively prevents the central portion and the edge portion of the filter 4 from being unevenly regenerated. When the ratio
25 of the closed area to the total area of the filter 4 is lower than 5 %, the closed area is not sufficient enough to effectively reduce the highest temperature inside the

filter during a filter regeneration process. Meanwhile, when the ratio of the closed area to the total area of the filter 4 is higher than 5 %, the closed area increases exhaust back pressure and thereby reduces the output power 5 of the engine 1.

In the present invention, various types of known fillers may fill in the ceramic honeycomb filter which is made of ceramic powder such as cordierite, zeolite or alumina. It is preferable to use a filler which is equal 10 to the ceramic powder of the cerami honeycomb filter.

The ceramic powder, which is formed into the ceramic honeycomb filter of the present invention, is preferably selected from a group of cordierite, zeolite, alumina, titania and zirconia. However, it should be understood 15 that the ceramic powder used in the present invention is not limited to the above-mentioned materials.

In addition, the ceramic honeycomb filter of this invention is effectively used for removing harmful particulate materials from the exhaust gas of a diesel 20 engine vehicle and may have a cell configuration selected from a group of doughnut-shaped, triangular, rectangular and hexagonal configurations. However, it should be understood that the cell configuration of the ceramic honeycomb filter of this invention is not limited to the 25 above-mentioned configurations.

In order to produce a ceramic honeycomb filter used with a diesel engine vehicle in accordance with the

invention, the ceramic powder is formed into a ceramic honeycomb filter having a plurality of cells. Thereafter, the cells of the honeycomb filter on both ends of the filter are alternately partially closed with a filler. In this case, the filler-plugged cells on one end of the honeycomb filter are aligned with the open cells on the other end of the filter. Thereafter, the central portion of the honeycomb filter is closed with the same filler, with a predetermined ratio of the closed area to the total area of the filter. In the present invention, it is possible to form a ceramic honeycomb filter by closing the central portion of a conventional ceramic wall flow filter, with a predetermined ratio of the closed area to the total area of the filter.

Fig. 10 is a view showing the construction of a harmful particulate removing device in accordance with the second embodiment of the present invention. In the device of the second embodiment, the exhaust gas flows from the right end to the left end of the device in the drawing in the same manner as described for the primary embodiment. The breather pipe 6 of the device according to the second embodiment has the same construction as that described for the primary embodiment but is installed on the exhaust pipes 2 and 2' in the back of the filters 4 and 4'. The trap valves 3 and 3' are installed on the respective exhaust pipes at positions behind the breather pipe 6. The device according to the second embodiment is operated

as follows. When one valve, for example, the valve 3 is closed and the electric heating means 5 associated with the valve 3 is turned on, the particulate materials accumulated on the filter 4 are burnt and removed from the filter 4 thus regenerating the filter 4. In this case, the exhaust gas from the engine is not directly applied to the filter 4 because the pressure inside the filter 4 is increased. However, a small amount of the exhaust gas including oxygen is indirectly fed to the filter 4 from the exhaust pipe 2' through the breather pipe 6 thus effectively burning the particulate materials accumulated on the filter 4 and regenerating the filter 4. The device according to the second embodiment thus yields the same result as that described for the primary embodiment without affecting the function of this invention.

Figs. 11a and 11b are views showing the breather pipes 6 of this invention used with harmful particulate removing devices which leak the exhaust gas into the atmosphere during a filter regeneration different from the devices of Figs. 1 and 10. As shown in Figs. 11a and 11b, the breather pipe 6 of this invention may be effectively used with a harmful particulate removing device which leaks the exhaust gas into the atmosphere during a filter regeneration.

The following examples and comparative example are merely intended to illustrate the present invention in further detail and should by no means be considered to

limitation of the scope of the invention.

Example 1 : checking of the leaking rate of exhaust
gas from a trap valve during a filter regeneration
5 process.

A bus engine, Model No. D 2366 (engine displacement:
11051 cc, maximum output power: 230 ps) manufactured by
Daewoo Motors of Korea, was installed on an engine DYNAMO
10 prior to installing a trap valve and a bypass valve of
this invention at positions between the exhaust manifold
and the exhaust pipe of the engine. A gas meter was
mounted to the exhaust pipe at a position in the back of
the trap valve in order to check the leaking rate of the
15 exhaust gas from the trap valve. Prior to checking the
leaking rate of the exhaust gas, the bypass valve was
opened, while the trap valve was closed. Thereafter, the
leaking rate of the exhaust gas from the rear end of the
trap valve was repeatedly checked by engine rpm. The
20 checking results are given in Table 1.

TABLE 1

25	RPM	600	1200	2200
	Leaking rate ml/min	3	7	17

Example 2 : checking of durability of a valve.

The trap and bypass valves included in the device of Example 1 were alternately and repeatedly opened and closed 30,000 times in an interval of 3 minutes. The leaking rate of the exhaust gas from the rear end of the trap valve was repeatedly checked by engine rpm. The checking results are given in Table 2.

TABLE 2

10	RPM	600	1200	2200
	Leaking rate ml/min	0	2	7

15 As well known from the above Examples 1 and 2, the exhaust gas leaks from the trap valve of this invention at a low leaking rate when the valve is closed, so that the trap valve of the invention allows the filters to be stably regenerated. The above trap valve also effectively
20 fills the micro-scratch of the valve metals caused by particulate materials included in the exhaust gas, thus remarkably improving the seal of the valve.

Example 3 : checking of a filter regeneration temperature.

20 % of kaoline, 40 % of talcum, 10 % of alumina, 20 % of aluminum hydroxide and 10 % of silica were mixed together into a mixture. The mixture in turn was heated for 3 hours at 1400 °C, thus forming cordierite powder.

5 Thereafter, the cordierite powder was mixed with a solution mixture at a weight ratio of 1 : 1 into a ceramic mixture. The above solution mixture consisted of phosphoric acid and ammonium silicate at a weight ratio of 10 : 1. The above ceramic mixture in turn was agitated

10 sufficiently thus forming filler slurry. The filler slurry was formed into two honeycomb wall flow filters A and B, each of which had a diameter of 5.66 inches and a length of 6 inches and had 100 cells per square inch. Thereafter, a truck engine, Model No. D4BA (engine

15 displacement: 2476 cc, maximum output power: 80 ps) manufactured by Hyundai Motors of Korea, was installed on an engine DYNAMO prior to passing the above filters A and B through a filter trap of the engine DYNAMO. Harmful particulate materials of the exhaust gas from the above

20 truck engine accumulated on the filters A and B. When the exhaust back pressure of either filter A, B reached an appropriate level, a heater installed in the filter trap was started to regenerate the filter. While regenerating the filter, the filter regeneration temperature was

25 checked at 5 positions inside the filter and the highest temperatures were recorded. After the filters A and B were regenerated, the above steps of checking the filter

regeneration temperatures were repeated by exhaust back pressure of the filters and the checking results are given in Table 3.

Comparative Example 1 : checking of a filter
5 regeneration temperature.

A honeycomb wall flow filter (having a diameter of 5.66 inches, a length of 6 inches and 100 cells per square inch and manufactured by Corning Co. Ltd of U.S.A) was installed on the filter trap of Example 3 and the process
10 of Example 3 was repeated. The checking results are given in Table 3.

TABLE 3

15	Remarks	Back Pressure, psi					
		1.3	1.5	1.6	1.8	2.0	2.2
20	Exam. A	654	757	772	836	931	928
	High. Temp. °C Exam. B	712	803	844	957	1080	1198
	Exam. C	875	914	965	1137	1266	break

As well known from Example 3, the ceramic honeycomb filters of this invention maintain adequate temperatures gradient during the filter regeneration process thus
25 maintaining good durability irrespective of repetitive

regeneration of the filters.

The operational effect of the device of this invention will be described hereinbelow.

when the engine 1 of Fig. 1 is started, the exhaust
5 gas from the engine 1 passes through the exhaust pipes 2
and 2', so that the harmful particulate materials are
filtered off by the filters 4 and 4' and accumulate on the
filters 4 and 4'. The two trap valves 3 and 3' are opened
until the particulate accumulating ratio of the filters 4
10 and 4' reaches 50 - 90 % of a predetermined regenerating
point, thus causing the particulate materials to be
filtered off by both filters 4 and 4'. However, when the
particulate accumulating ratio of either filter 4, 4'
exceeds the predetermined regenerating point, one valve 3,
15 3' associated with the selected filter 4, 4' is closed
under the control of a control program thereby starting to
regenerate the selected filter 4, 4'. In the above state,
the other filter associated with the opened valve
continuously filters the exhaust gas until the particulate
20 accumulating ratio thereof reaches the predetermined
regeneration point.

When the particulate accumulating ratio of the other
filter associated with the opened valve reaches the
predetermined regenerating point, both valves 3 and 3' are
25 opened for 1 minute. After 1 minute, the valve associated
with the filter which has continuously filtered off the
harmful particulate materials is closed to start a filter

regeneration process.

As described above, the filters 4 and 4' included in the device of this invention are alternately brought into the filtering and regeneration processes. When a valve 3, 5 3' is closed to start a filter regeneration process, air which is necessary to burn the particulate materials accumulated on the filter is fed to the filter while the electric heating means 5 is turned on. The heating coil 29 of the heating means 5 generates heat and starts to 10 burn the harmful particulate materials which accumulate on the filter at positions in vicinity to the heating coil 29. When the selected filter is heated as described above for 1 to 15 minutes, the front end of the filter having the particulate materials is heated to a temperature of 15 higher than 600 °C at which burning of soot can be continued without supply of the external heat. Therefore, even though the electric heating means is turned off at the above condition with air being continuously fed to the filter, the flame effectively and continuously propagates 20 from the front end to the rear end of the filter while completely burning and removing the harmful particulate materials inside the filter. Therefore, the filter is effectively regenerated and reused. Hereinbelow, the operational effect of the respective parts included in the 25 device according to this invention will be described in detail.

Each trap valve 3, 3' is operated as follows. When

the piston rod 23 of the cylinder 22 moves downward in Fig. 3, the connecting rod 20 rotates the shaft 19 clockwise thus rotating the hinged valve rod 15 clockwise. The valve body 14 is thus lifted up and allows the exhaust gas to flow from the exhaust inlet port 12 to the exhaust outlet port 13.

When it is necessary to close the exhaust inlet port 12 and to block the flow of the exhaust gas, the piston rod 23 of the cylinder 22 moves upward in Fig. 3, the connecting rod 20 rotates the shaft 19 counterclockwise thus rotating the hinged valve rod 15 in the same direction. The valve body 14 thus comes down and closes the exhaust inlet port 12 thereby blocking flow of the exhaust gas from the inlet port 12 to the outlet port 13.

When the valve body 14 closes the exhaust inlet port 12 and blocks the flow of the exhaust gas from the inlet port 12 to the outlet port 13, the valve body 14 does not form a gap between the valve body 14 and the valve seat of the inlet port 12 thus completely preventing leakage of the exhaust gas from the closed valve.

The breather pipe 6 is operated as follows. When the exhaust gas from the engine 1 fully accumulates on either filter, for example, the filter 4, the valve 3 associated with the selected filter 4 is closed thus preventing the exhaust gas from being introduced into the filter 4 prior to turning on the electric heating means 5 associated with the filter 4. The harmful particulate materials

accumulated on the filter 4 are thus completely burnt thereby regenerate the filter 4.

In the above state, the necessary oxidizer or air used for regenerating the filter 4 is included in the exhaust gas which is introduced from the exhaust pipe 2' into the filter 4 through the breather pipe 6 as shown in Fig. 4. In a typical diesel vehicle, the amount of air, which is practically supplied to the engine along with fuel, is remarkably larger than the ideally-required amount and thereby achieves complete combustion. Therefore, the exhaust gas from the engine 1 contains a large amount of air. That is, the concentration of oxygen in the exhaust gas from the engine 1 ranges from 8 % to 18 %. Of course, such a concentration of oxygen in the exhaust gas is lower than the oxygen concentration (21 %) of atmospheric air. However, the oxygen concentration (8 - 18 %) of the exhaust gas from the engine 1 is sufficient enough to effectively burn the harmful particulate materials accumulating on the filter 4 thus effectively regenerating the filter 4.

When the amount of air while feeding the exhaust gas containing oxygen to the filter 4 through the breather pipe 6 exceeds an appropriate level, the relief valve 7 of the breather pipe 6 is opened thus expelling a part of the exhaust gas into the atmosphere thereby maintaining an appropriate flow rate of air or oxidizer.

The above relief valve 7 is not frequently operated

but is selectively operated only in high load and leaking rate is ignorable, thus being less likely to cause air pollution.

The electric heating means 5 is operated as follows.

5 The heating coil 29 of the heating means 5 is brought into close contact with the filter 4 as shown in Figs. 6 and 7. When the particulate accumulating ratio of the filter 4 reaches a predetermined regenerating point, the valve 3 is closed prior to turning on the heating coil 29. The
10 heating coil 29 thus generates heat and starts to burn the harmful particulate materials which accumulated on the filter at positions in vicinity to the heating coil 29. When the filter 4 is heated as described above for a predetermined time, the front end of the filter 4 is
15 heated to a temperature of higher than 600 °C at which combustion can be maintained without the additional supply of the external heat. Therefore, even though the electric heating means 5 is turned off at the above condition with air being continuously fed to the filter 4, the combustion
20 flame effectively and continuously propagates from the front end to the rear end of the filter 4 while completely burning and removing the harmful particulate materials. Therefore, the filter 4 is effectively regenerated and reused. In this case, the heating coil 29 uniformly burns
25 the harmful particulate materials accumulated on the filter 4, so that the coil 29 can be operated with low electric current. The coil 29 is thus effectively

operated by a typical electric power source, which is typically installed in a vehicle, without using an additional battery or increasing the alternator's capacity.

5 As described above, the present invention provides a structurally-improved device for removing harmful particulate materials from the exhaust gas of the diesel vehicles. The device almost completely prevents the leakage of the exhaust gas from a closed valve during a
10 filter regeneration process. In the above device, an appropriate amount of oxygen or oxidizing agent, which is necessary while regenerating a filter, is effectively supplied from an opposite exhaust pipe to the filter through a breather pipe. The device thus has a simple
15 construction. In addition, the heating coil of an electric heating means is brought into close contact with an associated filter, thus being effectively operated by low electric current without using an additional battery or increasing the alternator's capacity. In the device of
20 this invention, the central portion of each filter may be saved from the adverse effects of the heating coil. Alternatively, the central portion of each filter may be blocked thus preventing the particulate materials from accumulating on the central portion of the filter.
25 Therefore, it is possible to prevent the central portion of each filter from overheating by heat accumulation, so that the filter is almost completely free from thermal

damage caused by such a high regeneration temperature gradient.

Although the preferred embodiments of the present invention have been disclosed for illustrative purposes,
5 those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

WHAT IS CLAIMED IS:

1. A device for removing particulate materials from the exhaust gas of the diesel vehicles, comprising:

an exhaust pipe extending from an exhaust manifold of
5 an engine and branched into two branch pipes;

valve means provided in at least one of said branch pipes and adapted for selectively opening or closing the branch pipe, said valve means being provided with a valve body for selectively opening or closing an exhaust inlet
10 port of a valve case;

filter means connected to at least one of said branch pipes and adapted for filtering off the particulate materials from the exhaust gas, the central portion of said filter means being closed with the ratio of the
15 closed area to the total area of the filter means ranging from 5 % to 40 %;

electric heating means installed on the front of said filter means in a way such that a heating coil of said heating means is brought into close contact with said
20 filter means, said electric heating means selectively burning and removing the particulate materials accumulated on said filter means thus regenerating said filter means when the particulate accumulating ratio of said filter means exceeds a predetermined regenerating point; and

25 a breather pipe extending between the two branch pipes at a position between the valve means and the filter means, thus causing the branch pipes to communicate with

each other through the breather pipe.

2. The device according to claim 1, wherein both said valve means and said breather pipe are installed in the front of said filter means.

5 3. The device according to claim 1, wherein both said valve means and said breather pipe are installed in the back of said filter means.

4. The device according to claim 1, wherein said valve body of the valve means is mounted to one end of a
10 hinged valve rod, the other end of said valve rod being fixed to a shaft and being rotated upward or downward by an actuating cylinder outside said valve case thus causing said valve body to selectively open or close the exhaust inlet port of the valve case.

15 5. The device according to claim 1, wherein both ends of said breather pipe reach the central axes of the branch pipes, respectively, thus minimizing variation of the air flow rate inside the breather pipe regardless of change of the operational condition of the engine.

20 6. The device according to claim 1 or 3, wherein a relief valve is mounted to a middle portion of said breather pipe, and prevents an excessive amount of oxygen from being introduced into said filter means while

regenerating the filter means.

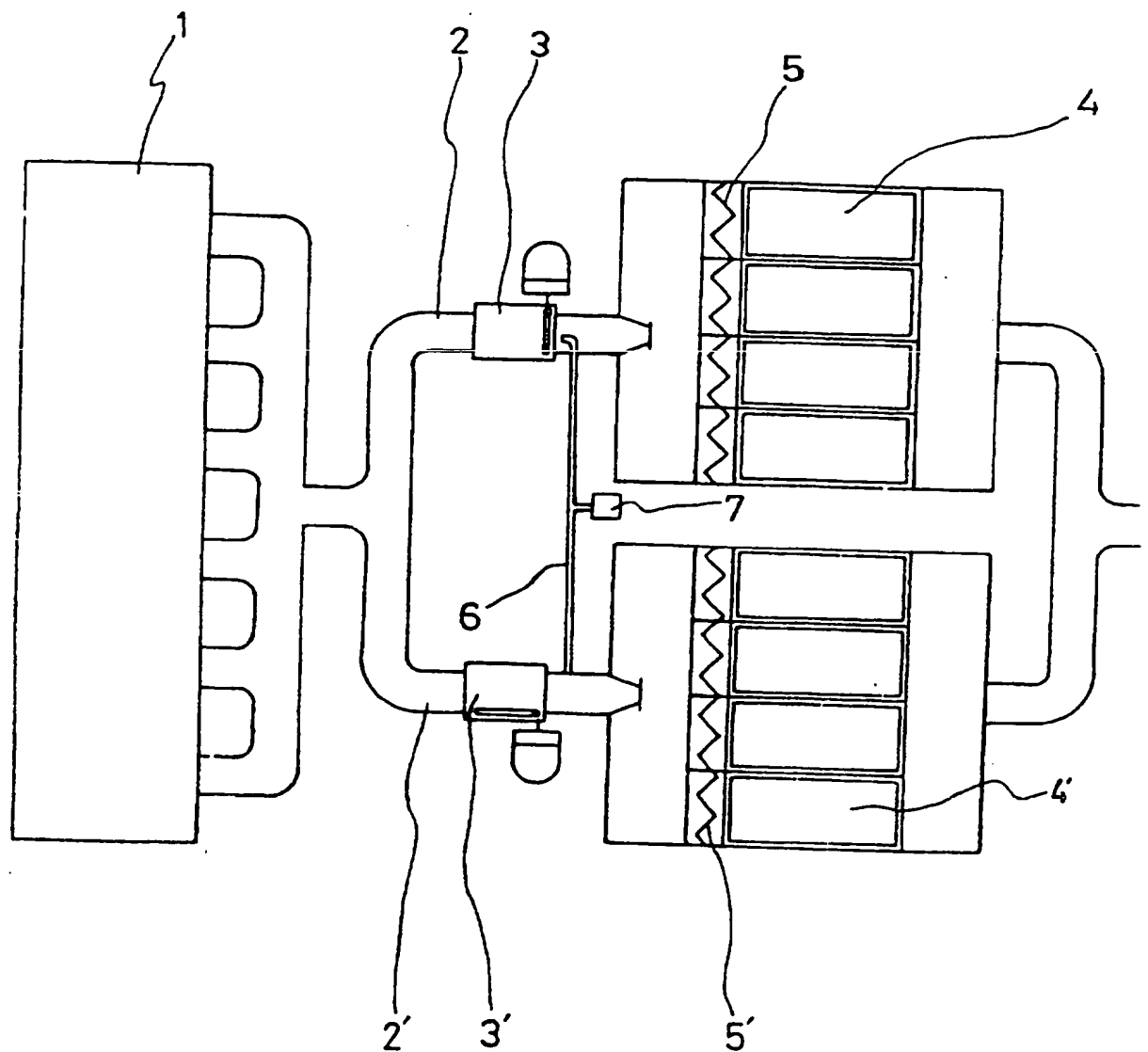
7. The device according to claim 1, wherein a heat reflector is received in a housing of said electric heating means and is perforated to form a plurality of exhaust openings, said heat reflector bringing said heating coil of the heating means into close contact with said filter means.

8. The device according to claim 7, wherein a plurality of coil holding protrusions are formed on said heat reflector and are adapted for holding the heating coil in its place thus preventing the heating coil from drooping or being bent due to heat generated from the heating coil.

9. The device according to claim 7, wherein the central portion of said heat reflector is brought into direct contact with said filter means without the heating coil being interposed between said central portion of the heat reflector and said filter means, thereby causing the central portion of said filter means to be saved from the adverse effects of the heating coil.

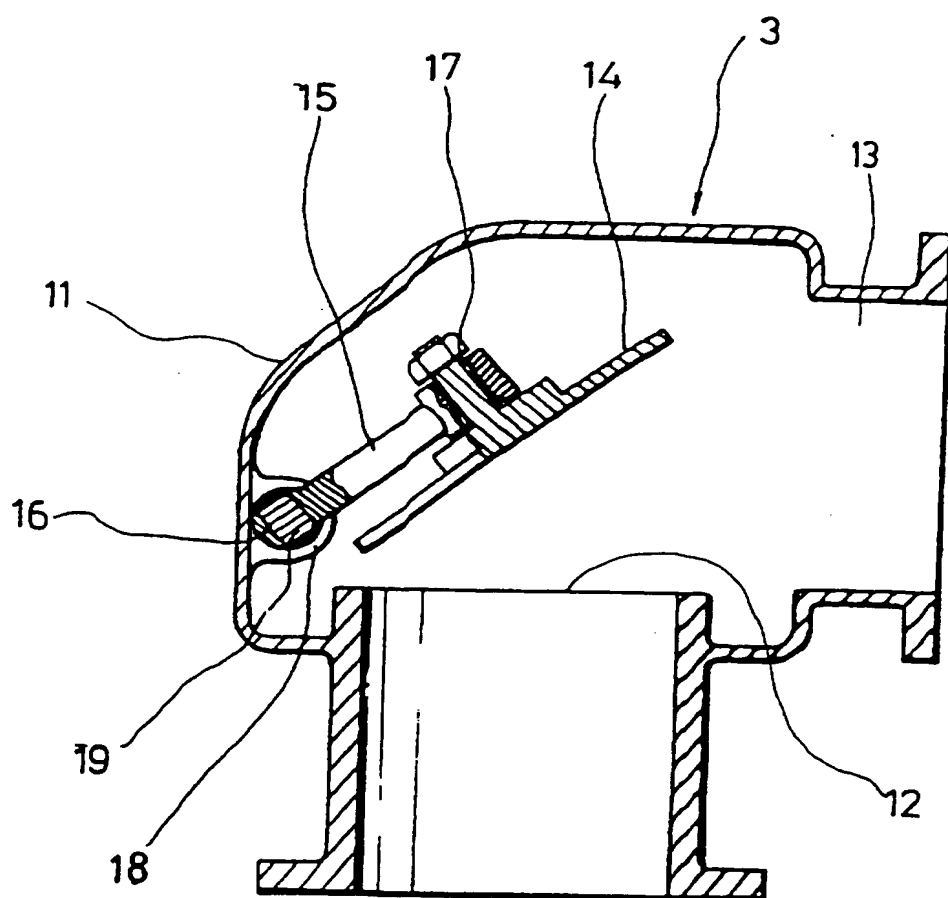
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FIG. 1



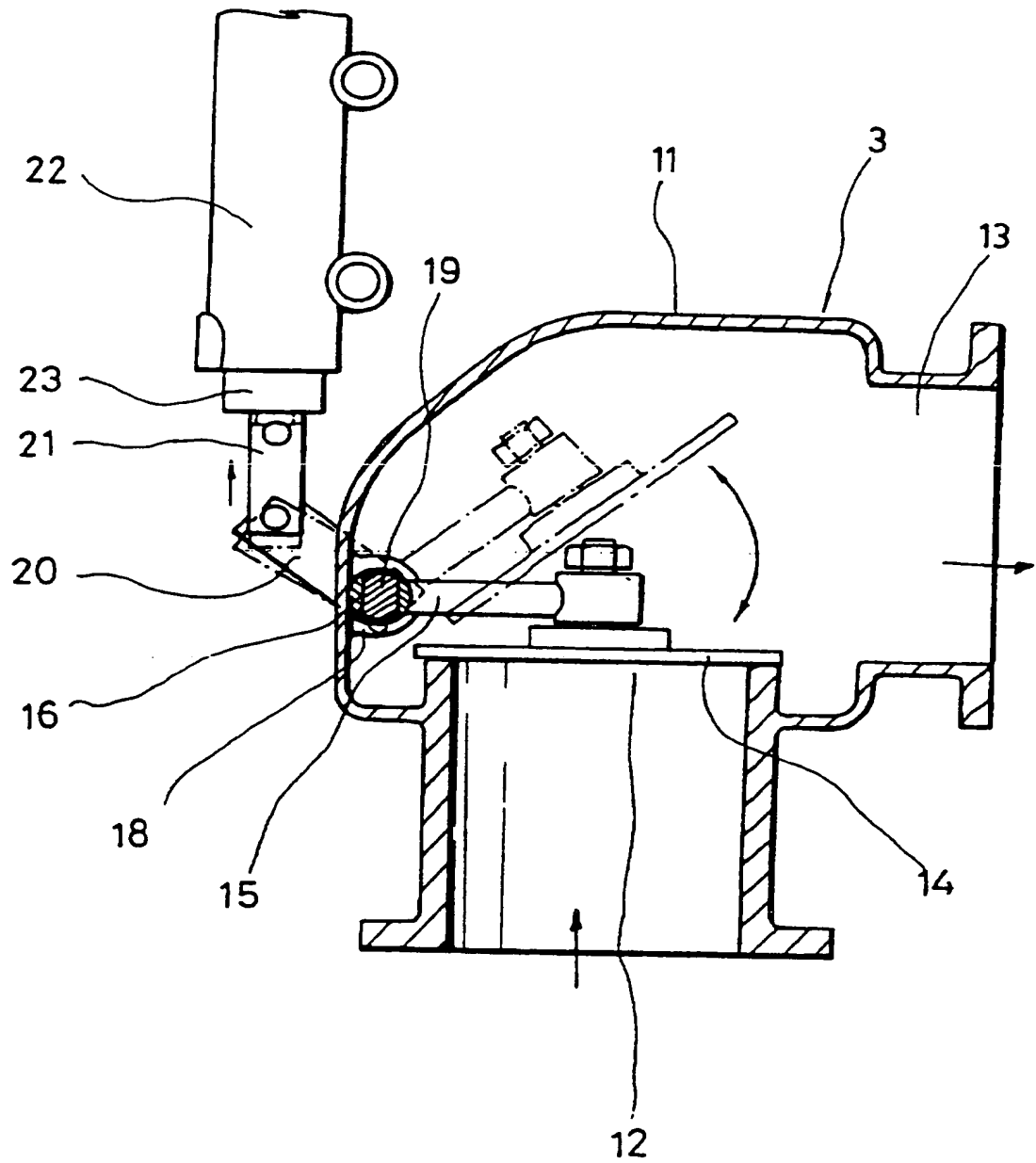
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FIG. 2



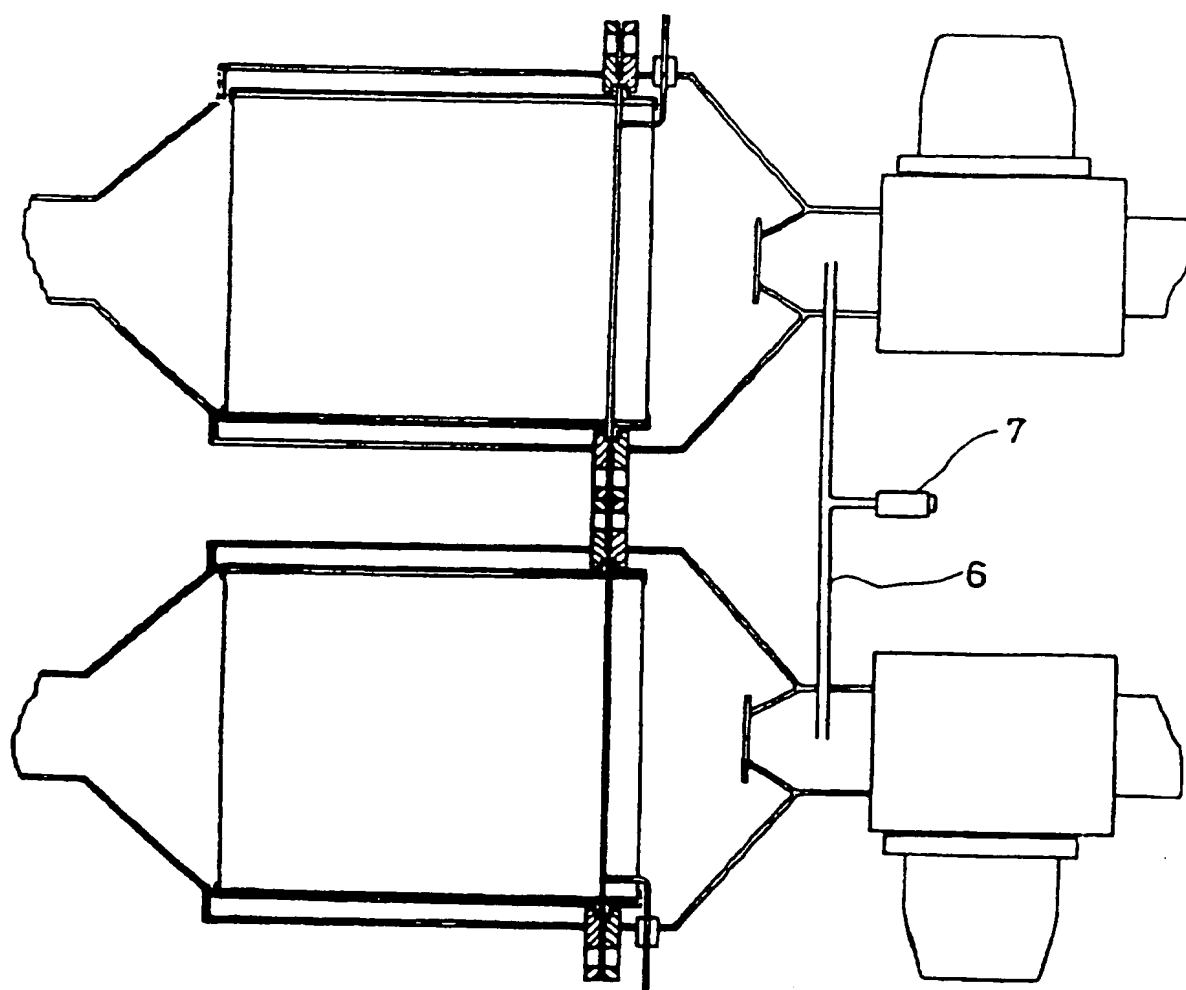
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FIG. 3



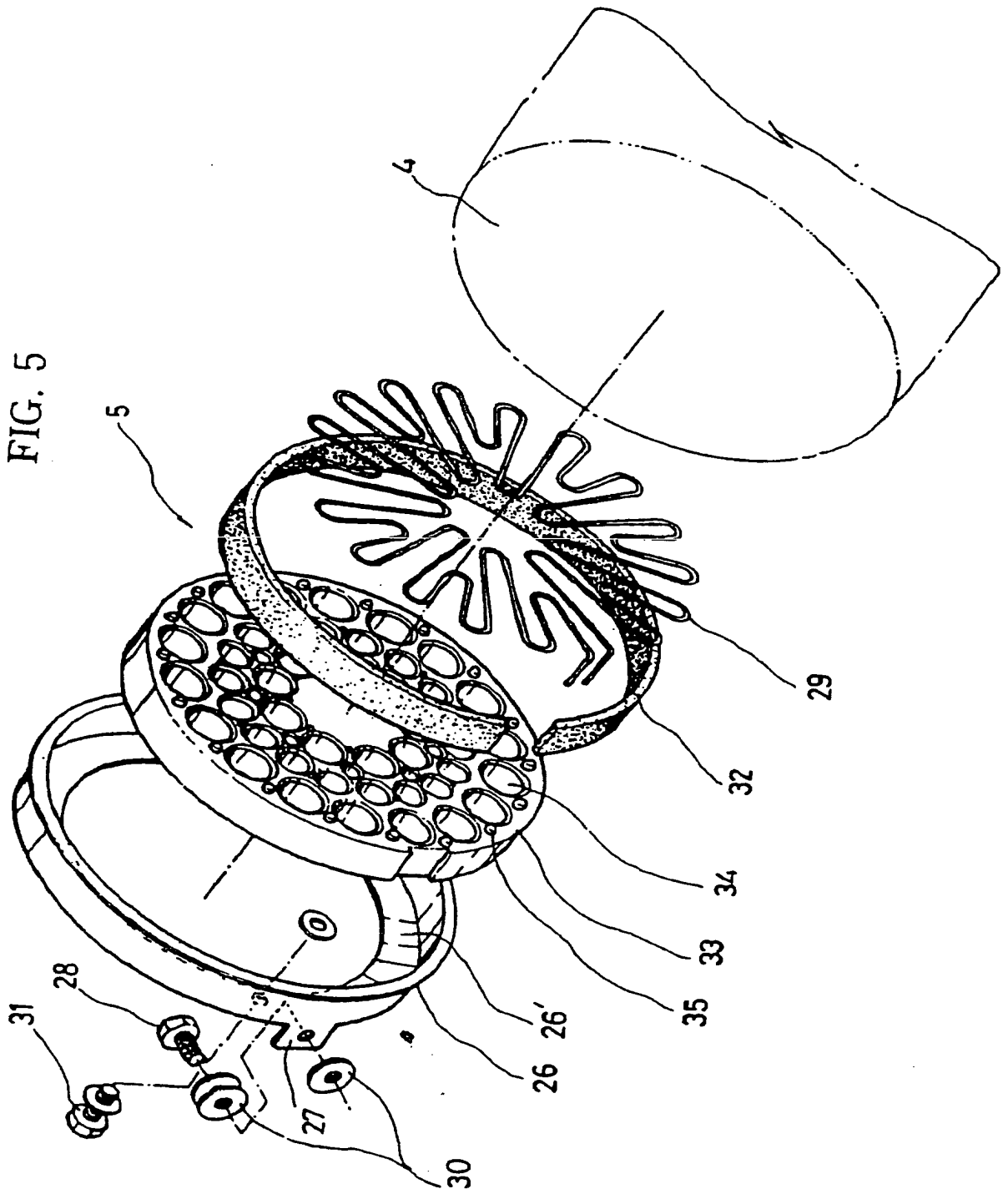
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FIG. 4



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FIG. 5



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FIG. 6

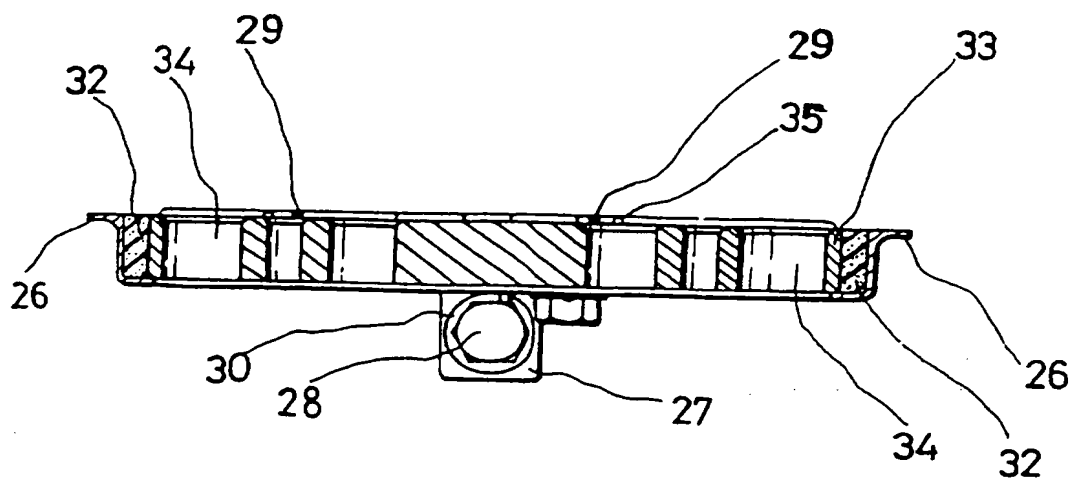
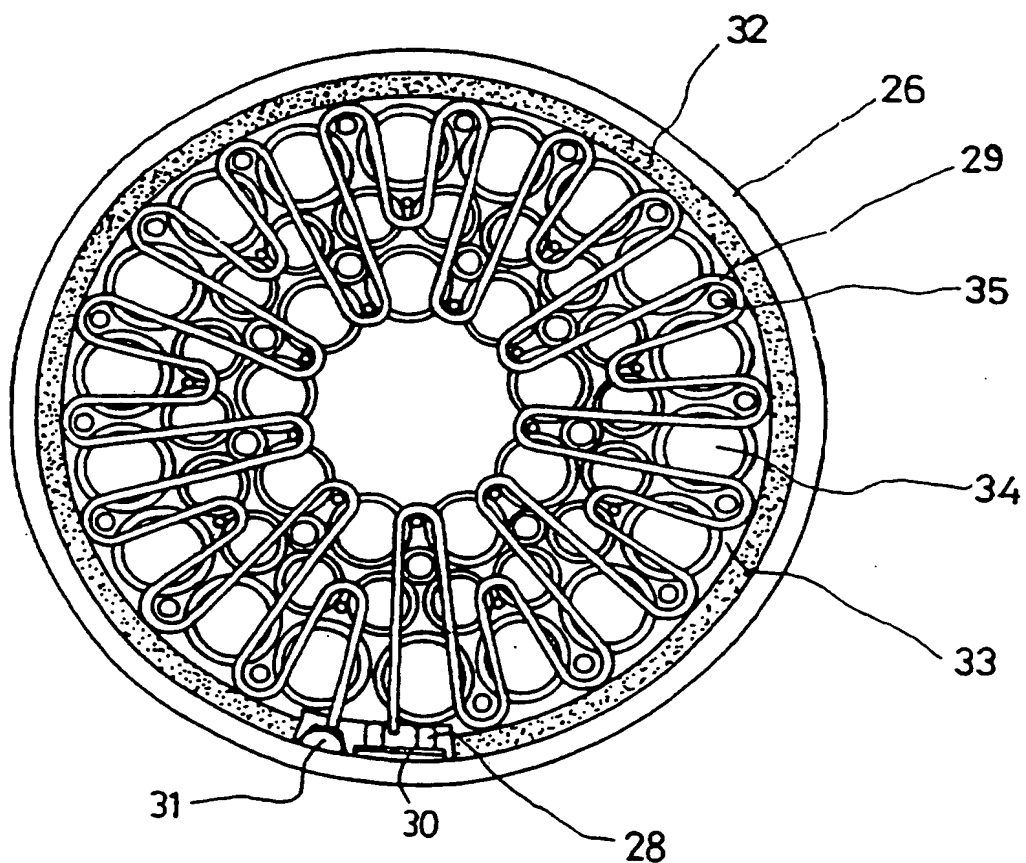


FIG. 7



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FIG. 8

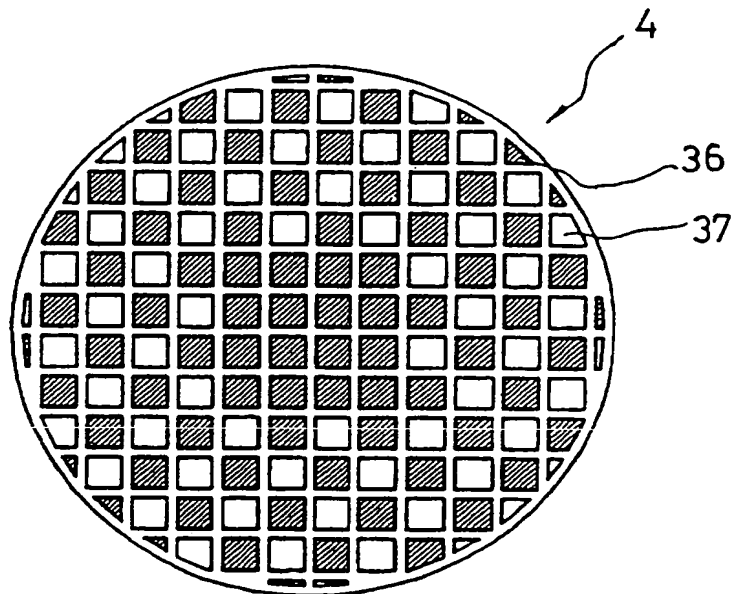
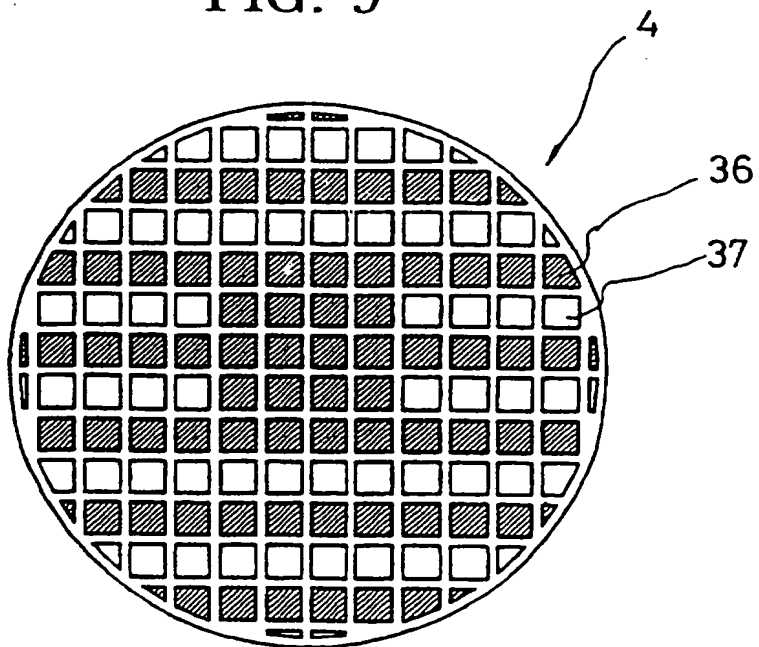
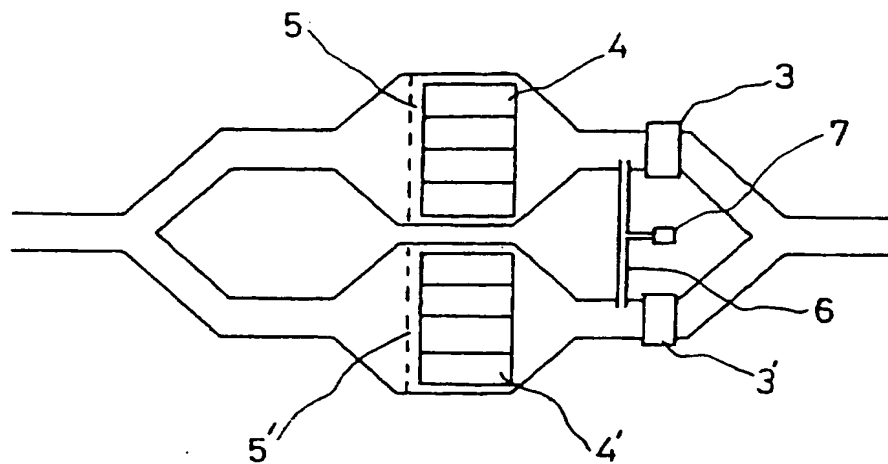


FIG. 9



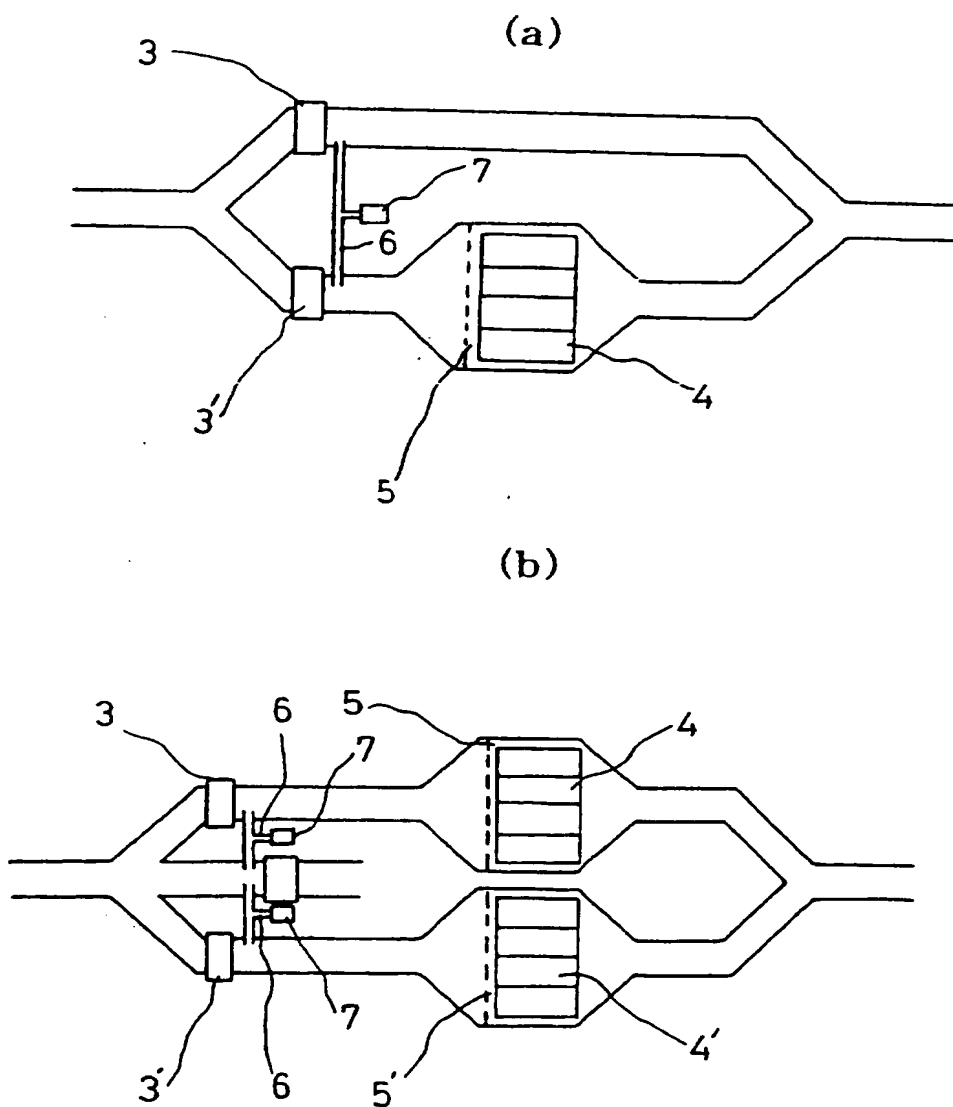
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FIG. 10



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FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR 96/00263

A. CLASSIFICATION OF SUBJECT MATTER

IPC⁶: F 01 N 3/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁶: F 01 N 3/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 558 565 A (KOJIMA et al.) 17 December 1985 (17.12.85), totality.	1
A	US 4 404 795 A (OISHI et al.) 20 September 1983 (20.09.83), fig.5,6. -----	1

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" documents of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is taken alone

"Y" documents of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of mailing of the international search report

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Name and mailing address of the ISA/ AT
AUSTRIAN PATENT OFFICE
Kohlmarkt 8-10
A-1014 Vienna
Facsimile No. 1/53424/535

Authorized officer

Pippan

Telephone No. 1/53424/359

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR 96/00263

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